FORAGE AND GRAIN YIELDS OF RYE AS AFFECTED BY SEEDING RATES AND CLIPPING

By

MANSOUR TAIEB

Agricultural Engineer

Institut National d'Agronomie

Tunis, Tunisia

1972

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
December, 1974

FORAGE AND GRAIN YIELDS OF RYE AS AFFECTED BY

SEEDING RATES AND CLIPPING

Thesis Approved:

F. E. LeGrand
Thesis Adviser

Billy B. Tucker

Wilfred E McMurphy

D D Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Frank E. LeGrand, major adviser, for his assistance, guidance, and encouragement throughout the course of this study. Gratitude is also extended to my advisory committee, Dr. Wilfred E. McMurphy and Dr. Billy B. Tucker for their constructive criticism, advice, and assistance in preparation of this thesis.

The valuable assistance of Dr. Robert D. Morrison, Professor of Mathematics and Statistics, during the statistical analyses of the data is gratefully acknowledged.

I am grateful to the Agronomy Department of Oklahoma State University and the Agency for International Development for the facilities and financial assistance which made this study possible.

Acknowledgement is given to Mrs. Kathy Roach for the spirit of cooperation and careful manner in which she typed this study.

To Mr. Ezedine Hatera sincere gratitude is expressed for his generous assistance and encouragement throughout the course of my education.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Rye (Secale cereale) is an extremely versatile crop. It can be used for pasture and silage or harvested for grain and is considered by farmers as an important asset in the economical production of livestock. The total forage production is not the only criterion used in the evaluation of rye and other small grains for pasture purposes. The period of production during the growing season is of prime importance.

In semi-arid and arid regions winter and spring moisture reserves often can be utilized by a quick growing cereal. The small grains have many characteristics that make them especially valuable as forage. Sprague (32) pointed out that yields are high and they are rich in protein, vitamins, and digestible carbohydrates. Elder (11) reported that winter pasturing of wheat (Triticum aestivum L.) grown primarily for grain has contributed greatly to Oklahoma's livestock production for many years. Other small grains like rye, oats (Avena sativa L.), and barley (Hordeum vulgare L.) are often planted primarily for winter and spring pasture without regard to grain production.

The research problem reported herein was designed to estimate the effect of seeding rate and different intensities of spring clipping on forage and grain yields of three varieties of rye: Elbon, Bonel and Okema. The objectives were: (1) to measure the relative effect of various clippings on forage and grain production; (2) to determine the maximum forage and grain production as influenced by variety, clipping intensity and seeding rate; (3) to determine the effect of last clipping date on grain production.

CHAPTER II

REVIEW OF LITERATURE

Rye belongs to the tribe Hordeae, to the sub-tribe triticeae and to genus Secale. The genus and species of cultivated rye is Secale cereale.

Theories of Origin

Rye appears to be a fairly new crop when compared to wheat and barley. It is not mentioned in the earliest writings and it was unknown to the ancient Egyptians and Greeks. Kent-Jones and Amos (18) stated that rye was not found in the remains of the Swiss Lake Dwellers or in the tombs of the ancient Egyptians. The earliest cultivation of rye appears to have been in western Asia and southern Russia. Klingman (20) reported that scientists believe rye was first noticed as a weed in wheat in central Europe. Then it was separated from the wheat and used as a new crop.

Brewbaker (3) mentioned that cultivated rye (Secale cereale) may have descended from <u>Secale anatolicum</u>, a wild form of rye which is found in Syria, Armenia, Persia, Afghanistan, Turkestan and the Kirghiz Steppe. Another opinion is that rye originated from <u>Secale montanum</u>, a wild species found in southern Europe and the adjoining parts of Asia and that it was grown as a cultivated plant in the Bronze Age. The similarity between species makes it impossible to prove which one originated from the other (39). Recently, Stutz (38) pointed out that from extensive cytological, ecological and morphological studies, it was concluded that cultivated rye originated from weedy products derived from introgressions of Secale montanum into Secale vavilovii.

Adaptation and Use

Rye can be grown in every state, but acreage is limited in most areas because other crops are more profitable. Being able to withstand severe winter climates, rye is the hardiest of all cereals adapted to the same area (4, 9, 21, 23). Delorit and Ahlgren (9) reported that rye germinates more rapidly, grows better at low temperatures, and is earlier maturing than wheat. Consequently its northern limit of culture extends beyond that of winter wheat. Savitskii and Nikolaev (29), Russian workers, found that the duration of growth in winter rye decreased from 170 to 130 days when the heat sum during this period was increased from 1465 to 1822 C. There was a linear negative correlation between air temperature and rainfall at any stage during the growth period.

Under semi-arid conditions, rye is only fairly drought resistant. It grows well upon almost all coarse textured soils--at least better than other cereals. Coffman (6) observed that rye generally outyielded wheat on the sandier dryland soils, while wheat outyielded rye on the so-called "hardlands". Reeves (27) stated that rye is often thought of as being adapted to poor or sandy soil because this is where it traditionally has been grown. Rye will generally outyield wheat, oats, or barley in infertile or sandy soils. This is because the soil requirements for rye are not as exacting as those for the other small grains. However, maximum yields are produced only on fertile soil. Rye will produce better on fertile, sandy soils and light loams than on heavy clay soils. It is more tolerant of dry soils than of wet, poorly-drained soils.

Rye is sometimes said to be "hard on the land" in the dryland areas because crops that come after it are often depressed in the yield. The explanation is undoubtedly in the root system. Weaver (43) found rye to have more lateral branches on the roots than do either oats or barley grown under the same conditions. The roots may branch profusely at the tips. This root system enables the plant to remove the available moisture more thoroughly than is possible by other cereals. However, Morey (23) stated that Georgia growers make extensive use of rye to improve soil before tobacco, corn, cotton, or many vegetable crops are planted. Tests have shown that a preceding rye crop will improve the appearance and quality of peanuts and may raise the yield by 8 percent.

As a general rule, rye is injured less by insects and diseases than the other cereals. Even though, it is more productive on fertile well-drained soils, it is seldom grown under such conditions because other small grains are more productive or bring a higher market price, and in consequence they provide larger financial returns per hectare. On the other hand, rye is more productive than the other cereals on sandy, acid, or infertile soils (9). In general, rye for grain is usually sown on soils which are not sufficiently fertile to grow other small grains profitably.

As far as the use of rye is concerned, Morey (23) reported that rye is the most important grazing crop in Georgia and several other southern states. In most years with proper management it can furnish excellent grazing from November until April. Feeding tests at Tifton have shown that ground or crushed rye grain can be substituted for half the corn in a fattening ration for hogs. Larger percentages of rye will result in less consumption and poorer gains.

A report from Texas by Stansel et al. (34) emphasizes the need for more attention to small grains for pasturage as they give good yield of highly palatable and nutritious forage. The pasturage is cheap feed, furnishes an excellent source of vitamin A when it is badly needed, and prevents winter leaching and erosion of the soil. Morrison (24) supports the report of Stansel et al, with the statement that small grains are very high in protein at the early stages of growth. Green rye, wheat or oats contain 20 to 25 percent protein if dried to the same moisture content as hay. Such forage is also very high in carotene and the B complex vitamins.

Small grain palatability tests conducted in Oklahoma by Staten and others (35, 36, 37) indicated cattle preferred winter barley, rye, soft wheat, ryegrass, oats and hard wheat in that order for fall grazing. In the spring they preferred soft wheat, hard wheat, oats, barley, rye and ryegrass in that order.

According to Shaw and Atkeson (30), the palatability may not be of prime importance in pasture crops, particularly when used alone, because cows will often do well on relatively unpalatable forages, if nothing else is available. Palatability would seem worthwhile for high-producing dairy cows when maximum feed intake is important. In this study using barley, wheat, common rye and Balbo rye, cows spent 52 percent of their grazing time on Balbo rye, 24 percent on common rye, 18 percent on wheat and 6 percent on barley.

In a study conducted at Tifton, Georgia, Morey (23) reported that between 120 and 140 days of winter grazing can frequently be achieved in south Georgia. Once the cattle become accustomed to the rye, the consumption is adequate for good gains. The forage is palatable and highly nutritious. The test has shown rye forage to be 2 percentage points higher in protein than oat forage (22 percent for oats, 24 percent for rye) on an oven dry basis. It can be used for feeding cows and calves, growing out feeder steers, or fattening heavier steers.

Several southern states have reported excellent daily gain and high beef production per hectare from winter grazing on cereal forages on the Southern Mississippi branch station (2). Winter grazing trials on the Batesville station in Arkansas showed oats producing daily gains of over 0.9 kg per head and 262 kilograms of animal gain per hectare annually (28). On the Coastal Plains Station in Georgia, oats and rye for winter pasture furnished 100 to 140 days of pasture and produced 277 to 417 kilograms of annual gain per hectare on beef cattle. In Georgia test, steers grazing on succulent oats and rye made weight gains equal to steers fed high grain rations in dry lot (31).

Seeding Rate Effect

There is a little information concerning the effect of seeding rate on the forage production and the grain yield of small grains. Denman and Arnold (10) stated that planting rates of small grains vary somewhat from eastern to western Oklahoma with generally heavier rates planted in the eastern region because of higher rainfall. Up to 50 to 100 percent heavier seeding rates are recommended in many areas for forage as compared to grain production. The hay is finer stemmed at higher seeding rates, but there is added danger of lodging. Holt, Norris and Lancaster (14) found that heavier seed rates in early seeding favor early autumn production and lower seed rates, which encourage tillering, produce just as much spring growth.

A series of trials was conducted by Mazurek and Mazurek (22) at 6 centers during 3 years to determine the influence of seeding rates (80, 120 and 160 kg/ha) on the yield of 4 rye varieties. Results showed that seeding rates did not delay the course of the different development phases of the varieties; the degree of lodging depended more on weather than on seeding rate; grain yields were similar from seedings of 120 and 160 kg/ha, but were reduced by a rate of 80 kg per hectare. With lower seeding rates there were increases in tiller number and in kernel weight. It was concluded that varying weather caused greater variation in fresh weight yield and yield components than did differences in seeding rates.

Nikolaev (26), a Russian worker, studied the effect of tillering on productivity of ears on stems of different orders. In this study winter rye was (a) sown at 7 million seed per hectare and (b) at a spacing of 1 square meter per plant. It was found that with (a), grain yields of the ears found on the tillers of the second order were 14-19 percent less than yields of the ears on the main stem; the ears on tillers of the third order yielded even less. The yield reduction is attributed to a decrease in ear length, number of grains per ear and kernel weight. With (b), plants produced an average of 9.16 tillers; the length and yield of ears formed on the first 3-5 tillers was about the same; the number of such tillers increased with increase in the total number of tillers.

Effect of Harvest Frequency on Forage and Grain Yields

Small grains are easier to harvest compared with a small grains-legume mixture. The stage of harvest is critical in determining feeding value. Klebsadel and Smith (19) harvested oats at four stages of maturity and reported greater dry matter yields from a single harvest in the late milk to mature stages than from 2 to 3 harvests made earlier.

The height of cut and degree of defoliation apparently is less important with small grains than with perennial grasses. Hubbard and Harper (15) observed a slight reduction in forage yield of several small grain varieties when severely defoliated as compared with moderate defoliation. Elder (11) found no difference in yield due to clipping height of small grain pasture. In his study he used stubble heights of 5 and 10 centimeters. Sprague (33) pointed out that a large amount of carbohydrates as reserves is stored in the lower leaf sheafs and stubble of orchardgrass and ryegrass. He concluded that it is reasonable to assume that a similar situation exists with the small grains since they are also grasses.

Holt (13) in his study, "Growth Behavior and Management of Small Grains for Forage," reported that frequent clipping results in reduced plant and reduced forage yields. A period of at least 4 to 6 weeks between clippings is necessary for recovery and regrowth. Height of clipping influences total plant development and rapidity of recovery following clipping but not total yield of harvested forage. According to Elder (11) yield of forage from small grains increased as the interval between cuttings was extended from 15 to 60 days. This response is similar to that reported for several perennial grass and legume crops both in the field and in the greenhouse.

Grain yield of rye, barley and hard and soft wheats were found by Jones et al (17) to be slightly reduced by clipping March 25 and drastically reduced by an April 14 clipping. It was found that oats clipped March 25 gave the highest grain yield. The most severe winter killing was observed in the non-clipped plots. Clipping to March 25 increased tillering in approximately one-half of the varieties studied, however it was noted that the number of tillers on some varieties might have been greater on plots clipped to March 25 because of more winter killing on non-clipped plots. Clipping to April 14 decreased the number of culms and resulted in a more prostrate growth habit and in less winter killing.

Investigation in midwestern and southern states have done much to determine the vegetative performance of different species and varieties of small grains over a wide range of climatic and soil conditions. Most of these trials have incorporated clipping practices simulating pasture conditions (8, 15, 42) rather than actual grazing, and a wide range of harvest schedules were used. Others have employed grazing by sheep (42) and beef cattle (5). Washko (42) in Tennessee found over 23 percent reduction in the yield of wheat grain following fall and spring grazing with sheep. Hubbard and Harper (15) in Oklahoma recognized in some instances slightly higher grain yields from plots clipped 4 or 5 times during the fall and winter up to March 15. Clippings after that date seriously reduced grain yields. Sprague (32) in his study, "Effect of Grazing on Forage and Grain in Rye, Wheat, and Oats," concluded that rye and wheat were alike with respect to season of maximum growth. Annual forage production of the two grains was about 14 percent higher when grazed both fall and spring compared with spring grazing only. In the spring of the year previously fall grazed wheat and rye yielded 25 to 30 percent less than the plots which are not grazed in the fall. This reduction was almost 45 percent with oats. When grazing was done during both fall and spring approximately one-third of the forage from wheat and rye was produced in the fall and two-thirds in the spring. This was not true with oats.

Warren et al. (41) reported that clipping every two weeks resulted in less forage and root growth than clipping every four weeks and found rye varieties produced more forage under frequent clipping than did oats, while oats were more productive than rye with less frequent clipping. In experiments in Oklahoma and Georgia it was found that winter rye produced more forage than either oats or wheat, but clipping any winter cereals for spring forage reduced grain yields (15, 25, 33). Clipping affected these cereal crops less in favorable growing season. The chemical composition of the forage was influenced by seasonal conditions but not the amount of growth removed by clipping. Aldrich (1) stated that repeated clipping reduced grain yields and kernel size of winter wheat.

In the Netherlands Gmelig (12) studied the grain yield of winter rye and winter wheat in relation to leaf number and leaf age. He reported that removal of the upper leaves of rye at heading gave lower yields of grain and straw than removal of the lower leaves; removal of all leaves reduced grain yields of winter rye by 44 percent and winter wheat by 43 percent. The proportional increase in stem weight after flowering compared with that or ear weight was appreciably greater in rye than in wheat. The effects of cutting early sown rye before winter and the role of the first leaves in seedling development from emergence until winter dormancy were studied in pot and field trials by Jackowska (16). Injury of plants during the development in early autumn and spring as well as final grain and straw yields was observed. Clipping of above-ground parts of rye plants at the time of the first frost did not reduce grain yields and gave better overwintering. Clipped plants had a larger root system, were more vigorous, started growth sooner and grew more uniformly than plants which were not clipped. It was also noted that grain yields were 4.3 and 6.7 kilograms per 20 square meter-plot in control plots (unclipped and clipped plots respectively). The increased yield was attributed to an increase in the number of ears per square meter, tiller number and kernel weight.

It was noted by Warren and Langille (40) that forage yields of winter rye, clipped in the spring in a series of 12 treatments, ranged from about 1.1 tons to over 4.4 tons of dry matter per hectare. Clipping reduced grain yields by at least 10 percent and several clipping treatments prevented any grain production. The lowest forage yield and the least reduction in grain yield resulted from a single early clipping. Increased forage yields were obtained when the interval between reported clipping was increased from a single early clipping. Increased forage yields were obtained when the interval between reported clipping was increased from 1 to 2, 3 or 4 weeks. Corns and Gupta (7) stated that increasing the number of cuts to 3 increased the grain yield of rye to 2.0 t/ha; there was no further increase with 4 clippings.

CHAPTER III

MATERIALS AND METHODS

This experiment was carried out in the 1973-1974 season at the Agronomy Research Station in Stillwater, Oklahoma. The growing season was marked by sufficient precipitation. Total season rainfall received from October, 1973 through June, 1974 was 664 mm. It was 104 mm. superior to normal. December, January, and February were characterized by low temperatures. Freezing during that period did not kill the plants; but the growth rate was very slow and insignificant. This explains why the first clipping was made on March 13, 1974.

The material evaluated in the study consisted of three rye varieties: Bonel, Elbon, and Okema. Elbon rye is a forage variety selected at the Noble Foundation and the Oklahoma Agricultural Experiment Station. It is the result of a cross made in 1954 between Florida Black rye and _Secale anatolicum_. Okema is similar to Elbon in appearance; it is slightly shorter than Elbon in height and is lower in test weight and yield. Okema has fewer hairs on the peduncle than Elbon. In fact some peduncles have almost no hairs. Okema would be the first winterhardy, greenbug resistant rye variety available to Oklahoma growers.

Field Layout and Characters Evaluated

The experimental design used for this study was a split-plot with factorial arrangement of main-plots seeding rate X variety. The sub-plots were the clipping effect, the number of clippings, and the effect of last clipping date. The main-plots were replicated four times.

The experiment was planted on October 9, 1973 at three seeding rates: 66.6, 83.3, and 100 kilograms per hectare (60, 75, and 90 pounds per acre, respectively). Prior to planting, 224 kg/ha of 18-46-0 ($N-P_2O_5-K_2O$) was applied over the plots. Each plot consisted of 13 rows, 23 cm. apart and 12.20 m. long. Rows 1, 2, 6, 8, 10, 12 and 13 were left as borders. Rows 3 and 5 were subjected to one clipping treatment; 7 and 9 were subjected to two clipping treatments. Row 11 was clipped four times. Rows 3, 4, 5, 7, and 9 were harvested for grain. The area clipped from each row was 2787 cm^2.

The characters evaluated were: a) forage yield, b) grain yield.

Forage Yield

The forage was clipped approximately 2.5 cm. above the ground with an electric clipped (shears) and a hand sickle. The clipping dates were as follows:

DATE	ROWS				
	3	5	7	9	11
March 13	X		X	X	X
March 18		X			
March 24			X		X
March 28				X	
April 4					X
April 14					X

After April 14 row 11 did not produce any more forage. The forage samples were placed in dryers at a temperature of 55 C for approximately one week. After the samples were dried, weights were recorded as grams per 2787 cm^2 plot.

Grain Yield

The grain was harvested by hand on June 14 and 15, 1974. The yield of grain was recorded in grams per 2787 cm^2 plot as it was removed from the thresher.

Statistical Analyses

The statistical analyses of variance for the data collected was analyzed on the IBM 360/65 Computer at the Oklahoma State University Computer Center. Analyses of variance were performed on traits to determine differences among varieties, seeding rates, cuts, clipping dates and their interaction. A separate analyses was made for forage and grain.

CHAPTER IV

RESULTS AND DISCUSSION

Forage and grain production estimates as influenced by varieties, seeding rates, number and date of clippings are presented under separate headings for simplicity and convenience of discussion.

Forage Production

Varieties and Seeding Rates Effect

Average forage yields for the varieties were as follows: Bonel 1341, Elbon 1337, and Okema, 1147 kilograms per hectare. Seeding rates and varieties had little effect on forage yield. Analysis of variance, shown in Table I, indicated no significant differences between varieties, among seeding rates or interaction.

At 66.6 kg/ha seeding rate, as shown in Figure 1, Elbon produced the highest amount of forage (1340 kg/ha) followed by Bonel (1235 kg/ha). Okema gave the least yield (928 kb/ha). At 83.3 and 100 kg/ha seeding rates Bonel yield exceeded both Elbon and Okema yields. However, it is interesting to note the rate of increase of Okema forage production when the seeding rate increased from 66.6 to 83.3 kg/ha. The rate of increase was the highest as compared to the other varieties.

Number of Clippings Effect

In Table I the analysis of variance indicated highly significant

TABLE I

ANALYSIS OF VARIANCE FOR VARIABLE FORAGE

Source	d.f.	Mean Squares
Reps	3	58,188.717
Varieties	2	740,699.246
Seeding Rate	2	826,169.289
Var. X S. Rate	4	190,500.885
Error (a)	24	385,414.429
Clippings	2	596,703.895**
Var. X Clippings	4	123,011.367
S. Rate X Clippings	4	28,848.956
Var. X S. Rate X Clippings	8	118,915.950
Error (b)	54	86,169.300

**Significant at 0.01 level of probability.

differences between the different clippings used in the experiment with regard to total forage yields. Mean square values showed no interaction between clippings, varieties, and seeding rates. All the varieties and seeding rates responded similarly to the clipping treatments.

The relationship between forage yield for each variety and of clippings (Figure 2, Table II) indicated that Elbon results were normal; but Bonel and Okema results were unexpected. In fact, rows 3 and 5 which were subjected to one clipping treatment produced more total forage than rows 7 and 9, which were subjected to two clipping treatments. Plots clipped four times produced an average forage yield of 1438 kg/ha

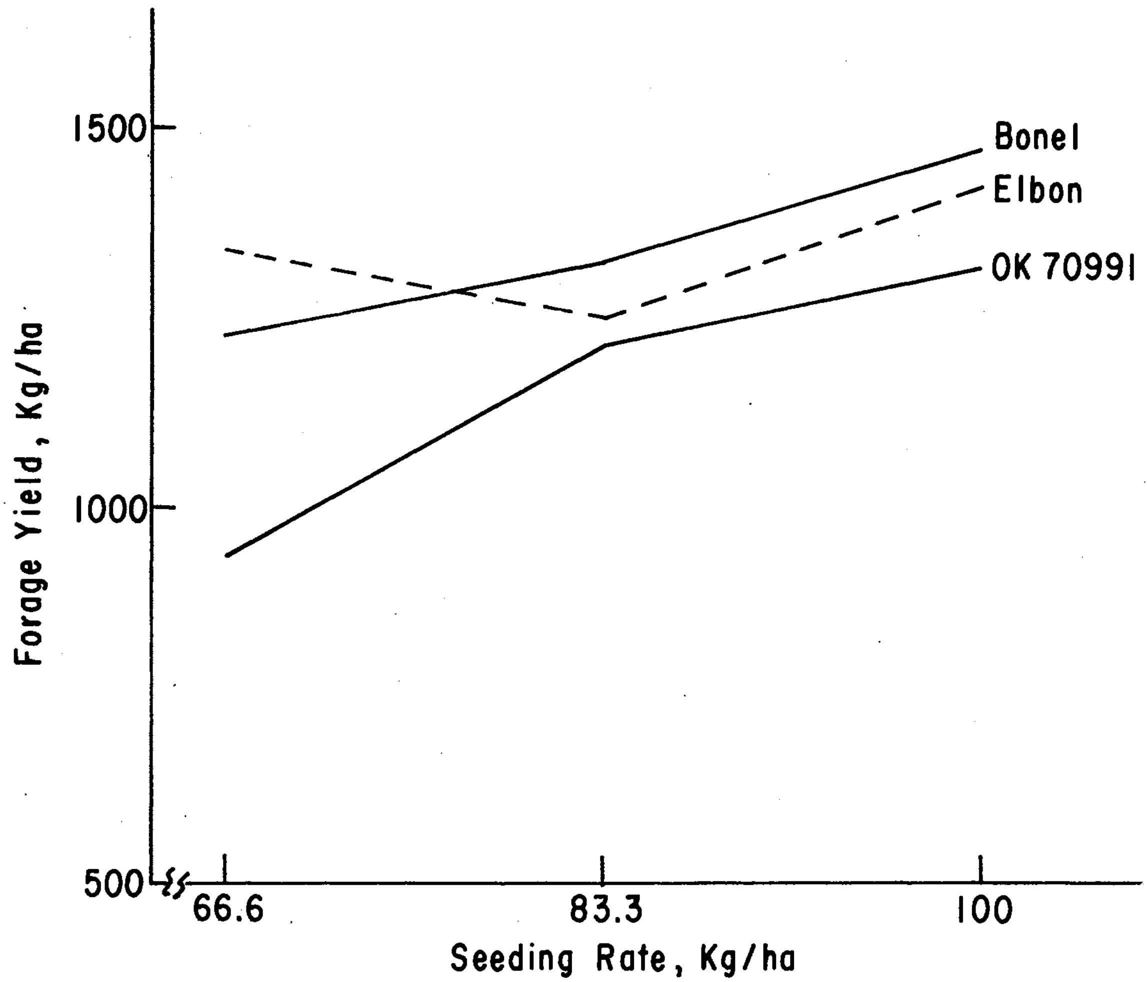

Figure 1. Average Forage Yields Per Hectare of the Three Rye Varieties as Affected by Seeding Rate. (OK 70991 is now Okema)

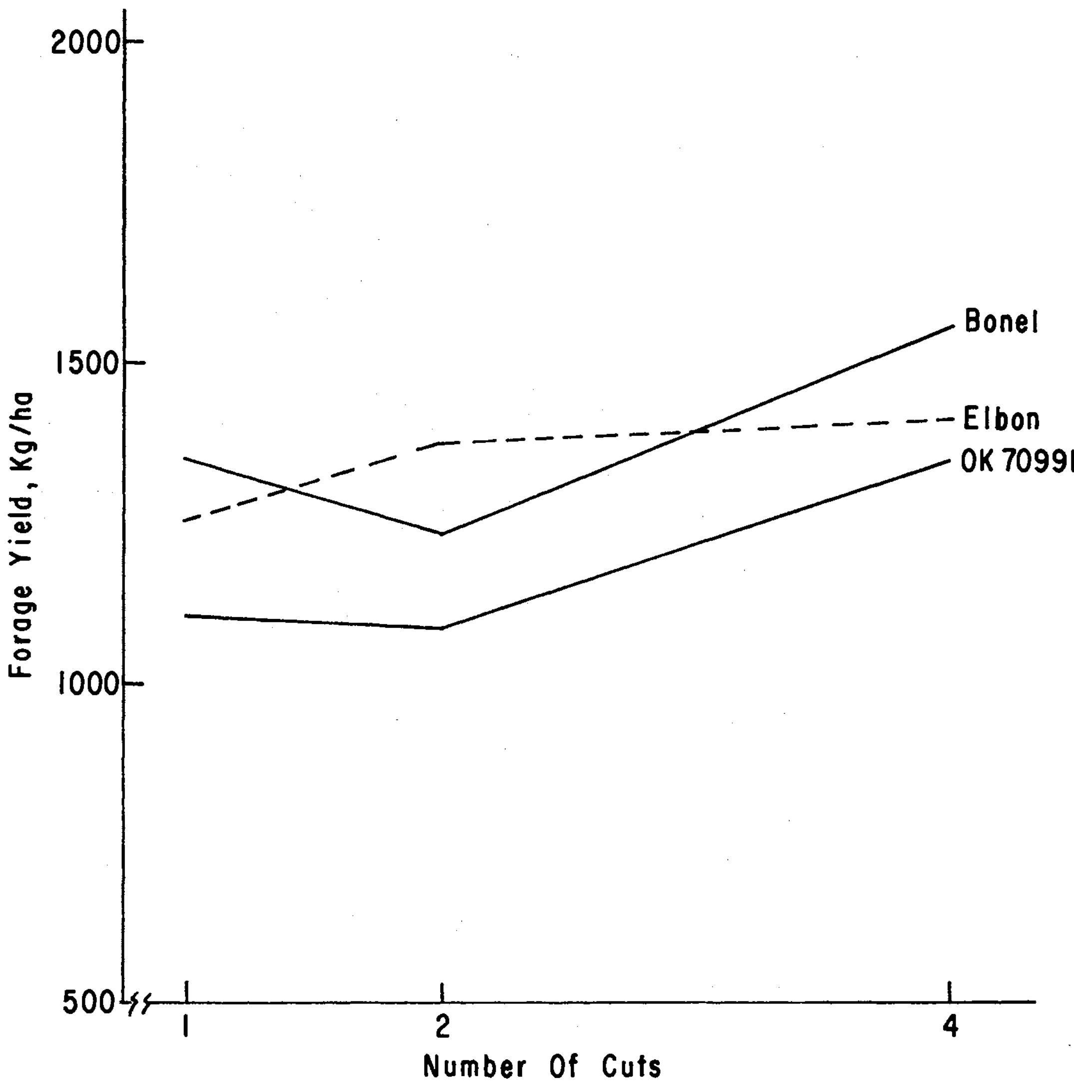

Figure 2. Average Forage Yields per Hectare of the Three Rye Varieties as Affected by Number of Clippings. (OK 70991 is now Okema)

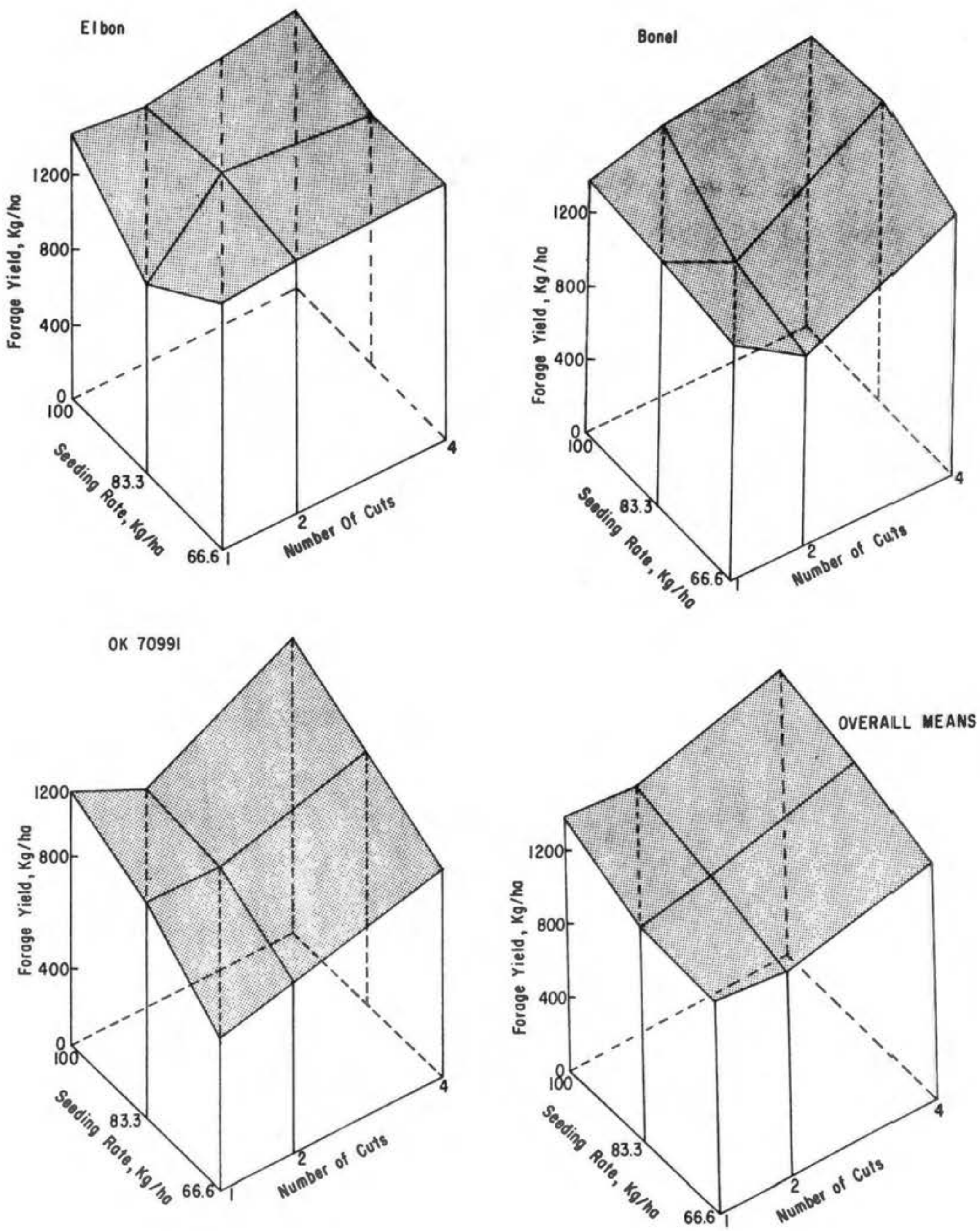

Figure 3. Influence of Seeding Rate and Number of Cuts on the Forage Yield of the Varieties - Elbon, Bonel, and Okema.

(OK 70991 is now Okema)

those clipped twice 1231 kg/ha and plots clipped once gave 1237 kg/ha of forage.

TABLE II

MEANS FOR FORAGE YIELD AT THREE DIFFERENT CLIPPINGS AND THREE SEEDING RATES

Variety	Clippings	Average Yield in Kilograms Oven-dry Forage per Hectare Seeding Rate in kg/ha 66.6	 83.3	 100	 Average
Bonel	1	1319	1332	1386	1346
	2	1054	1152	1494	1233
	4	1143	1637	1579	1549
Elbon	1	1328	1032	1428	1260
	2	1343	1424	1361	1376
	4	1359	1332	1543	1411
Okema	1	825	1166	1328	1106
	2	928	1155	1168	1084
	4	1130	1363	1565	1353
Average		1168	1257	1400	

Figure 3 shows no significant two-factor or three-factor interaction among varieties, seeding rates, and number of clippings.

Forage yields of each variety at three seeding rates and three different clippings are presented in Appendix Tables (Table IX, Table X, and Table XI).

Grain Production

Varieties and Seeding Rates Effect

Grain yields were found to be significant among varieties. There were no differences among seeding rates or interaction (Table III). Duncan's new multiple range test showed significant differences between Elbon and Okema. Elbon and Bonel were similar. Plots produced an average grain yield of 716 kg/ha for Elbon, 687 kg/ha for Bonel, and 540 kg/ha for Okema.

Figure 4 shows the relationship between grain yields and seeding rates. At 66.6 kg/ha-seeding rate Elbon and Bonel yields were approximately the same. At 83.3 kg/ha Bonel grain yield decreased. The rate of increase was the highest for Okema. More attention should be given to Okema to investigate its forage and grain yields potential when higher seeding rates are used. At 100 kg/ha seeding rate Elbon grain decreased.

Number of Clippings Effect

Statistically there were highly significant differences between the three clipping treatments on the total grain production. However, mean square values showed no interaction between clippings, seeding rates, and varieties. All varieties responded similarly to clipping treatments.

The relationship between grain yield and number of clippings (Figure 5, Table IV) showed a significant drop in the grain yield from no clipping (rows not clipped for forage) to two clippings. The plots which were not clipped for forage produced an average grain yield of

1590 kg/ha. The plots, clipped once, gave an average grain yield of 503 kg/ha. There was a decrease in grain yield of approximately 68 percent. The plots, which were clipped twice, produced an average grain yield of 321 kg/ha. In these plots the reduction in grain yield was about 80 percent when compared with the grain yield produced by the non-clipped plots for forage. Any forage harvesting treatment caused a reduction in grain yield. The loss following a single early clipping was the least of any treatment. It was noted that plots subjected to two cutting treatments produced less forage and less grain than plots which were subjected to one clipping treatment. Plots, clipped four times did not produce any grain. Warren et al (41) found that clipping every two weeks resulted in less forage and root growth than clipping every four weeks. The intervals between clippings used in this experiment were less than 15 days. This explains why the forage and the grain yields were low. It is necessary to allow the plants to build up stored food reserves at some period during the growth.

The analyses of variance for grain yield data, as for forage yield data, showed no significant two-factor or three-factor interaction among varieties, seeding rates and number of clippings. This can be noted by the four sketches shown in Figure 5. All the surface areas of the sketches have the same shape.

Grain yields of Bonel, Elbon and Okema at three seeding rates and three different clippings in each of four replications are presented in Appendix Tables (Table XII, Table XIII, and Table XIV).

TABLE III

ANALYSIS OF VARIANCE FOR VARIABLE GRAIN

Source	d.f.	Mean Squares
Reps	3	74,941.1
Variety	2	533,739.9*
Seeding Rate	2	25,060.6
Var. X S. Rate	4	76,362.0
Error (a)	24	128,570.4
Cuts	2	20,566,357.3**
Var. X Cuts	4	83,247.6
S. Rate X Cuts	4	134,586.4
Var. X S. Rate X Cuts	8	40,947.8
Error (b)	54	59,503.5

*Significant at 0.05 level of probability

**Significant at 0.01 level of probability

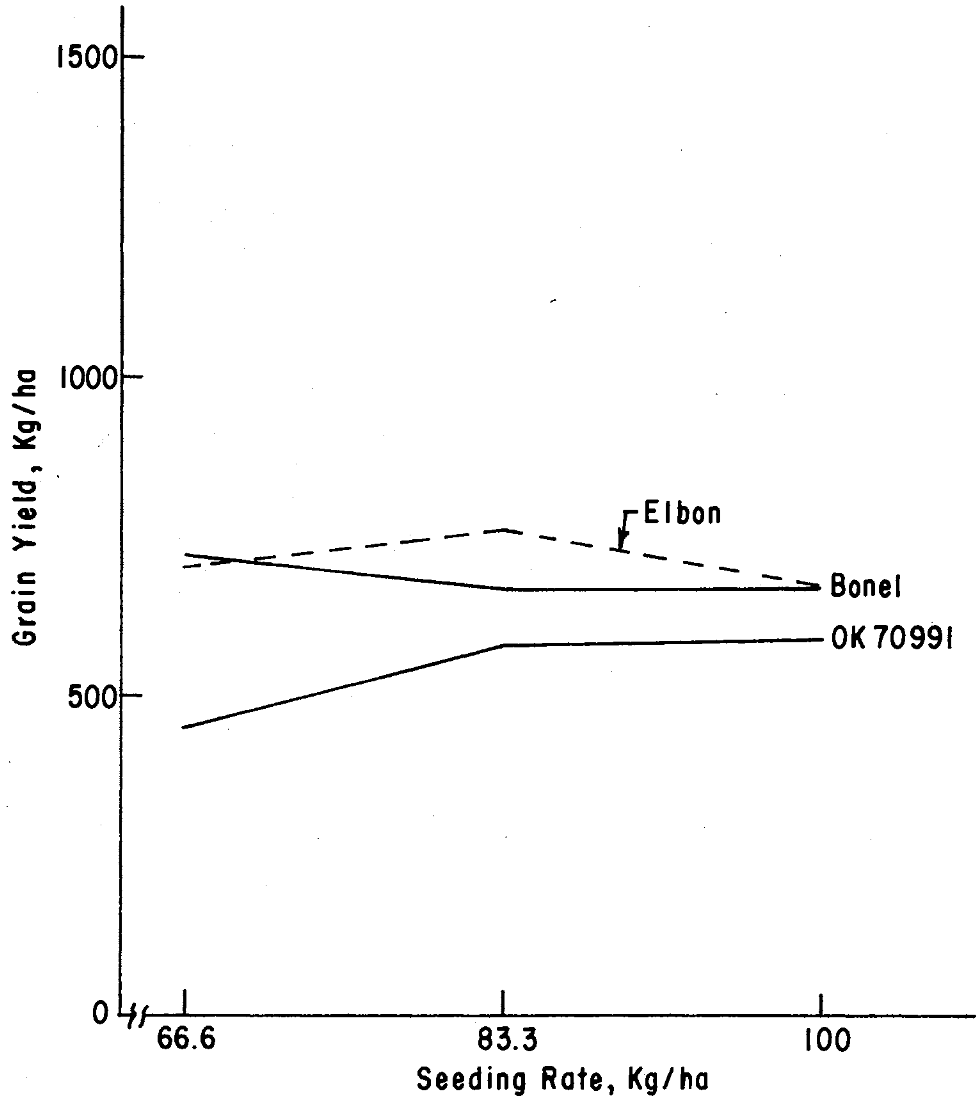

Figure 4. Average Grain Yields of the Three Rye Varieties as Affected by the Seeding Rate.

(OK 70991 is now Okema)

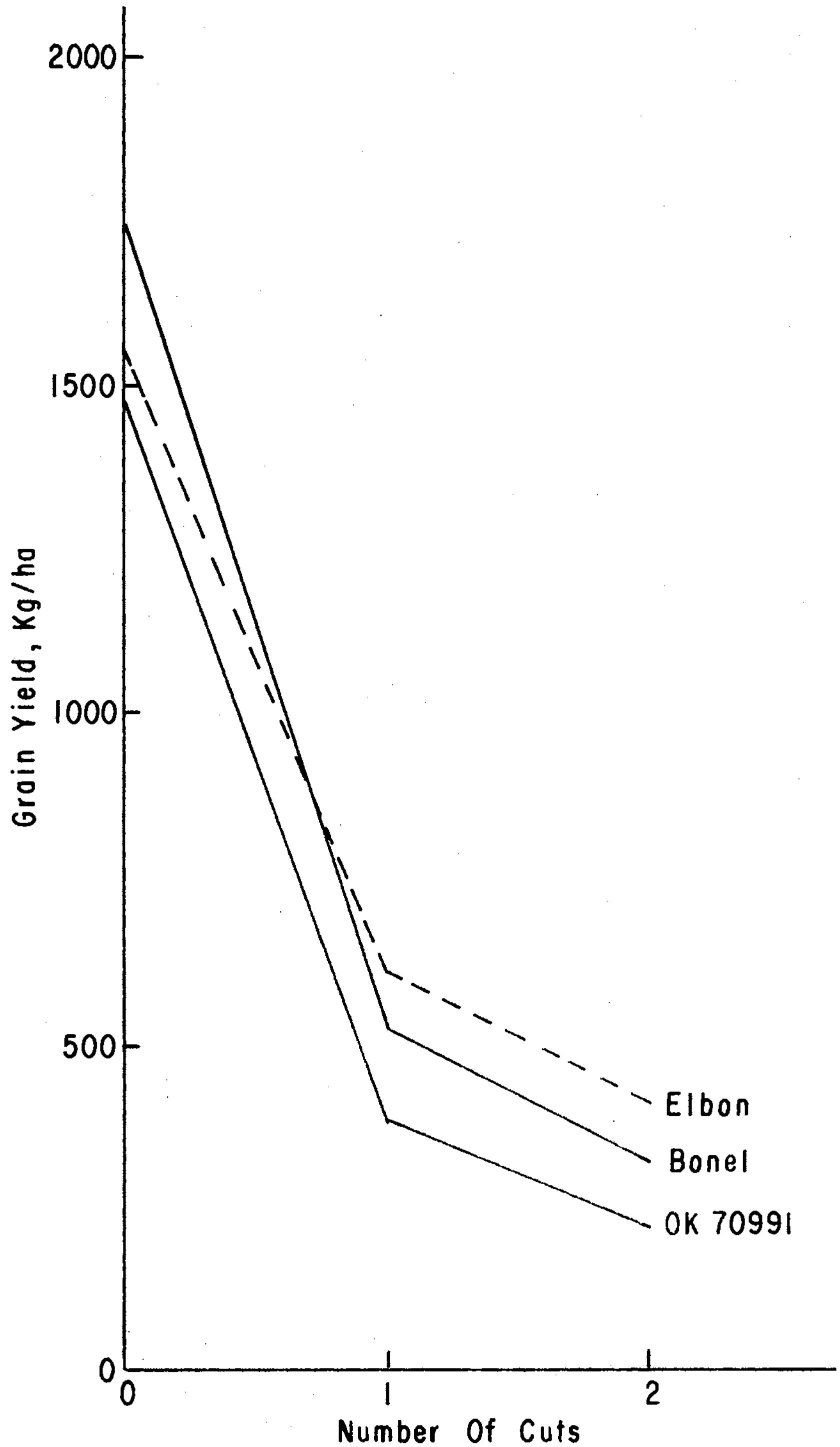

Figure 5. Average Grain Yields of the Three Rye Varieties as Affected by the Number of Clippings. (OK 70991 is now Okema)

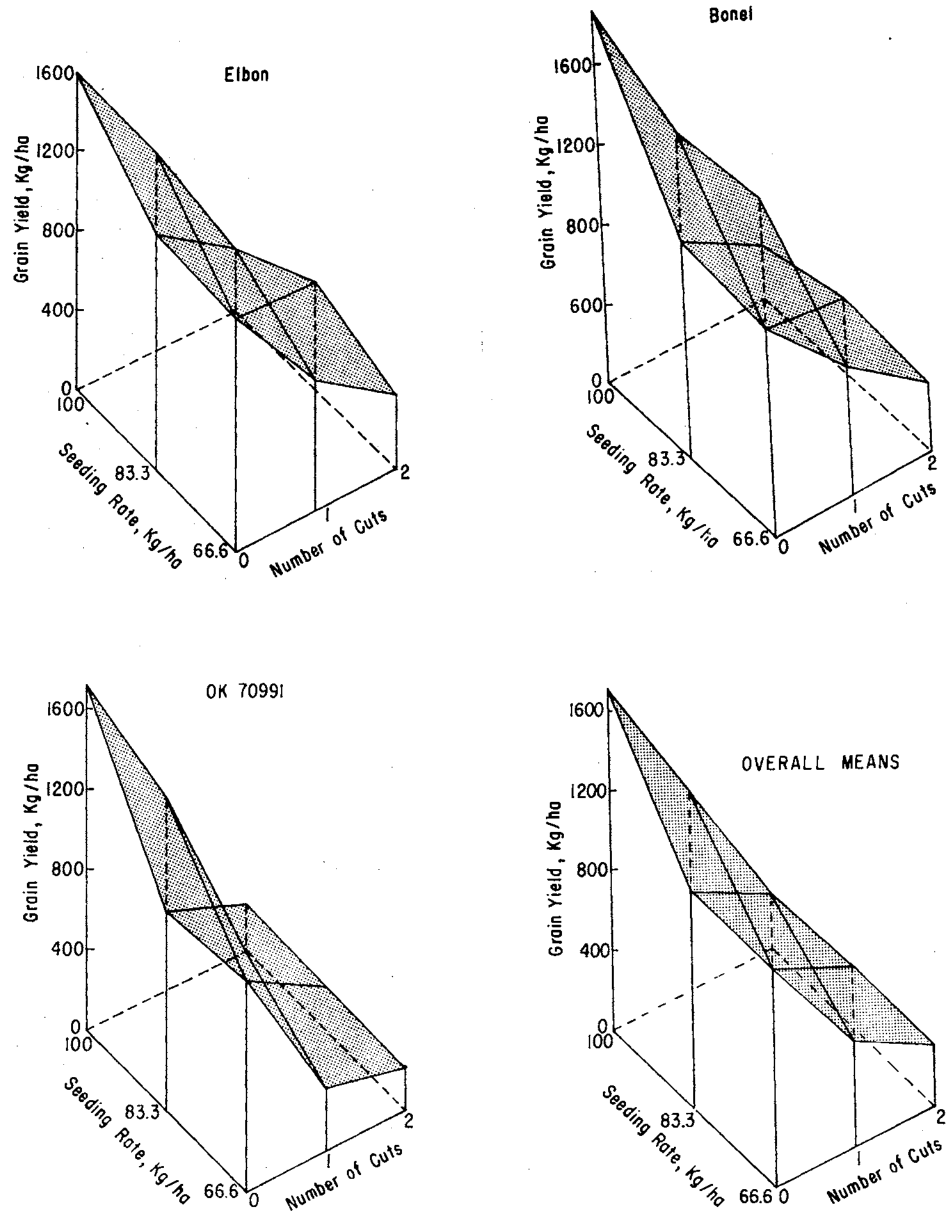

Figure 6. Influence of Seeding Rate and Number of Cuts on the Grain Yield of the Varieties - Elbon, Bonel, and Okema.

(OK 70991 is now Okema)

TABLE IV

MEANS FOR GRAIN YIELD AT THREE DIFFERENT CLIPS AND THREE SEEDING RATES

Variety	Clippings	Average Grain Yield in Kilograms per Hectare Seeding Rate in Kg/ha 66.6	83.3	100	Average
Bonel	0	1695	1650	1857	1734
	1	623	453	493	523
	2	336	386	260	327
Elbon	0	1489	1588	1588	1555
	1	650	565	588	601
	2	386	543	305	411
Okema	0	1184	1561	1695	1480
	1	309	453	395	386
	2	224	220	229	224
Average		628	669	645	

Last Clipping Date Effect

Rows 3 and 5 were clipped once but at different times. In each plot row 3 was clipped for forage on March 13; row 5 was clipped on March 18. Even though, there were 5 days between the two clippings analysis of variance, shown in Table V, indicated highly significant differences between grain yields produced by rows 3 and 5. The plots clipped early produced an average grain yield of 567 kg/ha. Grain yield averaged 439.5 kg/ha for the plots clipped late. The reduction was 22.5 percent. However, the forage yield produced by the early-clipped plots was lower than forage yield clipped later on March 18 (Table VI). Row 5 produced 42 percent more forage than did row 2.

TABLE V

ANALYSIS OF VARIANCE OF GRAIN DATA FOR ROWS CLIPPED ONCE

Source	d.f.	Mean Squares	Cal. F.	P F
Variety	2	285,221.983	5.1454	0.0136
Seeding Rate	2	10,745.888	0.1939	0.8263
Var. X. S. Rate	4	54,988.923	0.99239	0.5681
Error (a)	24	55,420.593		
Row	1	292,946.149	15.29309	0.0008
Var X Row	2	27,106.101	1.41506	0.2596
S. Rate X Row	2	12,998.770	0.67859	0.5200
Var X S. Rate X Row	4	36,814.949	1.9219	0.3149
Error (b)	27	19,155.455		

The varieties responded differently to the last clipping date effect. Duncan's multiple range test showed significant differences between Elbon and Bonel, and Between Elbon and Okema. Bonel and Okema responded similarly to that effect. There were no significant two factor or three factor interaction among varieties, seeding rates and last clipping date.

TABLE VI

AVERAGE FORAGE AND GRAIN YIELDS USING ROWS CLIPPED ONCE OF EACH VARIETY AT THREE SEEDING RATES

Variety	Row	Forage Seeding Rate			Grain Seeding Rate			Average	
		66.6	83.3	100	66.6	83.3	100	Forage	Grain
Bonel	3	1076	942	1193	807	440	601	1070	616
	5	1561	1722	1579	440	466	386	1621	431
Elbon	3	1238	942	1229	727	646	646	1136	673
	5	1417	1121	1615	574	484	529	1384	529
Okema	3	502	951	1121	314	511	413	858	413
	5	1148	1381	1533	305	395	377	1354	359
Average		1157	1177	1378	528	490	492		

TABLE VII

ANALYSIS OF VARIANCE OF GRAIN DATA
FOR ROWS CLIPPED TWICE

Source	d.f.	Mean Squares	Cal. F.	P F
Variety	2	210,286.844	3.63237	0.0408
Seeding Rate	2	84,232.746	1.45499	0.2524
Variety X S. Rate	4	32,416.465	0.55994	0.6966
Error (a)	24	57,829.505		
Row	1	350,448.274	13.05506	0.0015
Var. X Row	2	1,305.241	0.04862	0.9527
S. Rate X Row	2	30,270.864	1.12766	0.3393
Var. X S. Rate X Row	4	9,887.648	0.36834	0.8300
Error (b)	27	26,843.861		

TABLE VIII

AVERAGE FORAGE AND GRAIN YIELDS USING ROWS CLIPPED TWICE OF EACH VARIETY AT THREE SEEDING RATES

Variety	Row	Forage Seeding Rate			Grain Seeding Rate			Average	
		66.6	83.3	100	66.6	83.3	100	Forage	Grain
Bonel	7	1090	1162	1467	395	502	305	1239	401
	9	1018	1144	1520	278	269	215	1227	254
Elbon	7	1471	1440	1126	448	664	305	1345	472
	9	1251	1408	1597	323	425	305	1407	350
Okema	7	915	1049	1305	260	314	323	1090	299
	9	942	1260	1032	188	126	135	1078	149
Average		1109	1244	1341	315	383	265		

Rows 7 and 9 were clipped twice. The last clipping dates were March 24 for row 7 and March 28 for row 9. Eventhough, the intervals between the two clippings was four days analysis of variance for grain data (Table VIII) showed highly significant differences between last clipping dates. The early-clipped plots produced an average grain yield of 391 kg/ha. Plots clipped late produced an average grain yield of 251 kg/ha. There was a reduction of 36 percent. The forage produced by the two different rows was similar (Table VIII).

Duncan's multiple range test showed significant difference between Elbon and Okema. Elbon and Bonel were similar. There was no significant difference between Bonel and Okema. Mean Square values showed no significant two-factor or three-factor interaction among varieties, seeding rates, and last clipping date. The response of varieties and seeding rates was the same.

It would appear from the grain yield results that continued clipping of rye varieties, Elbon, Bonel and Okema sharply reduces grain production. This perhaps is due to damage or destruction of the older culms. Proportionately more severe grain yield reduction occured with later forage harvests.

CHAPTER V

SUMMARY AND CONCLUSIONS

A field experiment to study the influence of three seeding rates and to determine the effects of various clipping intensities on forage production and grain yield of rye was conducted in the 1973-1974 season at the Agronomy Research Station located in Stillwater, Oklahoma.

In this study three varieties of rye were used: Elbon, Bonel, and Okema. The seeding rates were 66.6, 83.3, and 100 kilograms per hectare (60, 75, and 90 pounds per acre respectively). A split plot design with factorial arrangement was used in this study. Seeding rate X varieties were the main plots while the sub-plots consisted of various clipping intensities. The main-plots were replicated four times. Each plot consisted of 13 rows, 23 cm. apart and 12.20 m. long. Rows 1, 2, 6, 8, 10, 12 and 13 were left as borders. Rows 3 and 5 were subjected to one clipping treatment; row 3 was clipped 5 days earlier than row 5. Rows 7 and 9 were subjected to two-clipping treatments. For the last clipping row 7 was harvested 4 days earlier than row 9. Row 11 was clipped 4 times and did not produce any more forage. Rows 3, 4, 5, 7, and 9 were harvested for grain. The area clipped from each row was 2787 cm^2.

From the results the following conclusions seem to be justifiable:

1. Although varieties and seeding rates or interaction did not significantly affect the forage production

it is interesting to note the rate on increase of Okema forage yields when higher seeding rates were used. The rate of increase was the highest as compared to Elbon and Bonel forage yields.

2. There were highly significant differences between the various clipping treatments with regard to total forage production. All the varieties responded similarly to the treatment. The highest yield was obtained when the clipping was made late or when the plots were clipped four times.

3. Grain yields of the three rye varieties were found to be significant among number of clippings and last clipping date. Among the varieties studied, Okema, from the standpoint of total grain production appeared the least desirable. For the plots clipped twice the last clipping date reduced the grain yield of about 36 percent.

4. Any forage clipping treatment caused a reduction in grain yield. The loss following a single early clipping was the least of any treatment.

5. Later or more frequent forage harvests resulted in more severe grain yield reduction. In this experiment four clipping treatment prevented any grain production.

LITERATURE CITED

1. Aldrich, D. T. A. 1959. The Effect of Grazing Management on the Response of Winter Wheat to Spring Defoliation. Empire J. Exptl. Agri. 27:10-16.

2. Blount, C. L. 1958. Winter Grazing Results, South Mississippi, 1951-1957. Mississippi Agri. Exp. Sta. Bul. 555.

3. Brewbaker, H. E. 1926. Studies of Self-fertilization in Rye, Minn. Agri. Exp. Sta. Tech. Bul. 40.

4. Briggle, L. W. 1959. Growing Rye, USDA Farmers Bul. 2145.

5. Burton, G. W., Parkham, S. A., Southwell, B. L., and Stephens, J. L. 1949. Winter Grazing in Georgia Coastal Plains. Georgia Coastal Plain Exp. Sta. Bul. 47.

6. Coffman, F. A. 1925. Experiments with Cereals at the Akron Field Station in 15-Year Period, 1908-1922. U. S. Dept. Agri. Bul. 1287.

7. Corns, W. G., and Gupta, R. K. 1971. Winter Survival, Forage and Grain Yields of Spring-Seeded Winter Wheat and Winter Rye Mowed Once or Several Times Before Winter. Can. J. of Pl. Sci. 51:211-214.

8. Cutler, G. H., Pavez, D., and Mulvey, R. R. 1949. The Effect of Clipping to Similate Pasturing Winter Wheat on Growth, Yield, and Quality of the Crop. Agron. J. 41:169-173.

9. Delorit, R. J. and Ahlgren, H. L. 1960. Rye, Crop Production. 2nd Ed. Prentice Hall, N. J.

10. Denman, C. E., and Arnold, James. 1970. Seasonal Forage Production for Small Grain Species in Oklahoma. Okla. Exp. Sta. Bul. 680.

11. Elder, W. C. 1960. Grazing Characteristics and Clipping Responses of Small Grains. Okla. Exp. Sta. Bul. 567.

12. Gmelig Meyling, H. D. 1971. Grain Yields of Winter Rye and Winter in Relation to Leaf Number and Leaf Age. The Netherlands Journal of Agri. Sci. 19:250-256.

13. Holt, E. C. 1962. Growth Behavior and Management of Small Grains for Forages. Agron. J. 54:272-275.

14. Holt, E. C., Norris, M. J., and Lancaster, J. A. 1969. Production and Management of Small Grains for Forage. Tex. Agr. Exp. Sta. Bul. 1082.

15. Hubbard, V. C., and Harper, H. J. 1949. Effect of Clipping Small Grains for Forages. Agron. J. 41:85-92.

16. Jackowska, I. 1971. The Role of Autumn Development of Early Sown Plants in the Over-Wintering and Productivity of Winter Rye, Pamietnik Putawski. 47:55-77.

17. Jones, M. D., Smith, H. S., Muncrief, E., and Staten, H. W. 1944. Forage Production of Small Grains and Ryegrass. Okla. Agr. Exp. Sta. Mimeo. Cir. No. M. 114.

18. Kent-Jones, D. W., and Amos, A. J. 1957. Modern Cereal Chemistry, 5th ed. Liverpool: Northern Publ. Co. pp. 1-817.

19. Klebsadel, L. J., and Smith, Dale. 1960. Effect of Harvesting an Oat Companion Crop at Four Stages of Maturity on the Yield of Oats, on Light Near the Soil Surface, on Soil Moisture, and on the Establishment of Alfalfa. Agron. J. 52:627-630.

20. Klingman, G. C. 1961. Crop Production in the South. John Wiley and Sons, Inc. New York.

21. Martin, J. H., and Smith, R. W. 1923. Growing Rye in the Western Half of the United States. USDA Farmers Bul. 1358.

22. Mazurek, Jan, and Mazurek, Jadwiga. 1969. Influences of the Sowing Rate on the Yield of Rye Varieties at Two Levels of Nitrogen Fertilizing. Pamietnik Putawski. 36:187-200.

23. Morey, D. D. 1972. Rye, Southern Style. Crops and Soils. 37:12-14.

24. Morrison, F. B. 1950. Feeds and Feeding. Ithaca, New York. Morrison Publishing Company.

25. Morris, H. D. and Gardner F. P. 1958. The Effect of Nitrogen Fertilization and Duration of Clipping Period of Forage and Grain Yields of Oats, Wheat and Rye. Agron. J. 50:454-457.

26. Nikolaev, M. E. 1970. Effect of Tillering on Productivity of Ears on Stems of Different Orders. Sb. Nauch. Trud. Beloruss. Sel. - Khoz. Akad. 64:242-246.

27. Reeves, D. L. 1971. Do You Have a Rye Future Ahead. Crops and Soils. 23:15-17.

28. Sandal, P. C., Staten, R. D., and Davis, A. M. 1953. Pasture Experiments on North Arkansas. Arkansas Agri. Exp. Sta. Bul. 537.

29. Savitskii, M. S., and Nikolaev, M. E. 1971. Vegetative Period of Winter Rye in the Belorussian SSR and its Agrometeorological Characters. Referativnyi Zhurnal, 55 No. 8, 329.

30. Shaw, A. O. and Atkeson, F. W. 1942. Comparative Palatability of Some Cereal Pastures. Jour. Dairy Science 25:503-506.

31. Southwell, B. L. and Parham, S. A. 1955. Annual Winter Grazing in the Coastal Plain of Georgia. Georgia Agri. Exp. Sta. Mimeo. Series 3.

32. Sprague, M. A. 1954. The Effect of Grazing Management on Forage and Grain Production from Rye, Wheat and Oats. Agron. J. 46:29-33.

33. Sprague, M. A. 1966. Cereals as Forage. Forages by Hughes, H. D., Heath, M. E., and Metcalfe, D. S. 337-345.

34. Stansel, R. H., Dunkle, P. B., and Jones, D. L. 1937. Small Grains and Ryegrass for Winter Pasture. Texas Agri. Exp. St. Bul. 539.

35. Staten, H. W. 1944. Palatability Test of Winter Pasture Crops. Okla. Agri. Exp. Sta. Mimeo. Cir. M-115.

36. Staten, H. W., and Elder, W. C. 1946. Forage Production of Winter Small Grain Varieties and Annual Ryegrass. Okla. Agri. Sta. Mimeo. Cir. M. 161.

37. Staten, H. W., and Heller, V. G. 1949. Winter Pasture. Okla. Agri. Exp. Sta. Bul. 333.

38. Stutz, H. C. 1972. On the Origin of Cultivated Rye. American Journal of Botany. 59:59-70.

39. Vavilov, N. I. 1917. On the Origin of Cultivated Rye. Bul. Appl. Bot., 10:561-590.

40. Warren, F. S., and Langille, J. E. 1964. Effect of Management on Forage Yield and Subsequent Grain Production on Winter Rye. Can. J. of Pl. Sci. 45:153-158.

41. Warren, F. S., Riordon, H. A., and Langille, J. E. 1963. Forage Production with Different Clipping Frequencies of Rye and Oats Alone and in Mixtures in the Greenhouse. Can. J. Pl. Sci. 43:469-474.

42. Washko, J. B. 1947. The Effects of Grazing Winter Small Grains. Agron. J. 39:650-666.

43. Weaver, J. E. 1926. Root Development of Field Crops. McGraw-Hill. PP. 162-166.

APPENDIX

TABLE IX

FORAGE YIELD OF BONEL RYE AT THREE DIFFERENT SEEDING RATES AND THREE DIFFERENT CLIPPING INTENSITIES IN EACH OF FOUR REPLICATIONS

Seeding Rate Kg/ha	Cut	Row	Yield in Kilograms Oven-dry Forage per Hectare Replications 1	2	3	4
66.6	1	3	1076	1005	1041	1184
66.6	1	5	1399	1256	2225	1363
66.6	2	7	1148	1076	843	1292
66.6	2	9	1148	861	969	1094
66.6	4	11	1274	1417	1543	1489
83.3	1	3	969	1005	897	897
83.3	1	5	1794	2153	1722	1220
83.3	2	7	1220	1256	1256	915
83.3	2	9	1076	1525	915	1058
83.3	4	11	1686	1920	1310	1633
100	1	3	1363	1435	969	1005
100	1	5	1973	1579	1435	1328
100	2	7	1758	1722	1399	987
100	2	9	1399	1650	1076	1955
100	4	11	1363	2153	1435	1363

TABLE X

FORAGE YIELD OF ELBON RYE AT THREE DIFFERENT SEEDING RATES AND THREE DIFFERENT CLIPPING INTENSITIES IN EACH OF FOUR REPLICATIONS

Seeding Rate Kg/ha	Cut	Row	Yield in Kilograms Oven-dry Forage per Hectare Replications			
			1	2	3	4
66.6	1	3	1615	861	1255	1220
66.6	1	5	1076	1543	1794	1256
66.6	2	7	1058	1005	2494	1326
66.6	2	9	1005	718	2189	951
66.6	4	11	1112	736	2081	1507
83.3	1	3	1041	897	781	1112
83.3	1	5	718	1507	1005	1256
83.3	2	7	933	1363	987	2476
83.3	2	9	1471	1473	538	2171
83.3	4	11	1381	1328	879	1740
100	1	3	1076	1399	1328	1112
100	1	5	789	1650	3014	1005
100	2	7	861	915	2081	646
100	2	9	1484	1722	1058	1758
100	4	11	1094	1848	1435	1794

TABLE XI

FORAGE YIELD OF OKEMA RYE AT THREE DIFFERENT SEEDING RATES AND THREE DIFFERENT CLIPPING INTENSITIES IN EACH OF FOUR REPLICATIONS

Seeding Rate Kg/ha	Cut	Row	Yield in Kilograms Oven-dry Forage per Hectare Replications			
			1	2	3	4
66.6	1	3	466	359	646	538
66.6	1	5	861	1148	1041	1543
66.6	2	7	825	610	1076	1148
66.6	2	9	1005	933	861	969
66.6	4	11	1399	933	736	1453
83.3	1	3	969	861	682	1292
83.3	1	5	1435	1615	897	1579
83.3	2	7	1363	915	700	1220
83.3	2	9	1561	1076	1041	1363
83.3	4	11	1274	1597	825	1758
100	1	3	1041	1005	1112	1328
100	1	5	1973	1220	1615	1328
100	2	7	1381	1023	1274	1543
100	2	9	1148	897	1184	897
100	4	11	1902	1184	1507	1668

TABLE XII

GRAIN YIELD OF BONEL RYE AT THREE DIFFERENT SEEDING RATES AND THREE DIFFERENT CLIPPING INTENSITIES IN EACH OF FOUR REPLICATIONS

Seeding Rate Kg/ha	Cut	Row	Grain Yield in Kilograms per Hectare Replications			
			1	2	3	4
66.6	1	3	538	718	1076	897
66.6	0	4	2225	1435	1328	1794
66.6	1	5	431	431	538	359
66.6	2	7	431	538	359	251
66.6	2	9	538	108	359	108
83.3	1	3	431	359	538	431
83.3	0	4	1615	1435	1866	1686
83.3	1	5	359	359	718	431
83.3	2	7	538	431	610	431
83.3	2	9	179	179	359	359
100	1	3	359	2153	610	718
100	0	4	1794	2153	1328	2153
100	1	5	108	359	538	538
100	2	7	72	359	538	251
100	2	9	00	179	431	251

TABLE XIII

GRAIN YIELD OF ELBON RYE AT THREE DIFFERENT SEEDING RATES AND THREE DIFFERENT CLIPPING INTENSITIES IN EACH OF FOUR REPLICATIONS

Seeding Rate Kg/ha	Cut	Row	Grain Yield in Kilograms per Hectare Replications			
			1	2	3	4
66.6	1	3	1076	610	431	789
66.6	0	4	1794	1866	969	1328
66.6	1	5	969	466	431	431
66.6	2	7	718	359	179	538
66.6	2	9	789	179	78	251
83.3	1	3	897	538	789	359
83.3	0	4	1615	1794	1686	1256
83.3	1	5	538	538	610	251
83.3	2	7	1435	359	610	251
83.3	2	9	359	359	789	179
100	1	3	1076	359	538	610
100	0	4	1686	2153	1256	1256
100	1	5	431	610	538	538
100	2	7	251	431	179	359
100	2	9	359	359	72	431

TABLE XIV

GRAIN YIELD OF OKEMA RYE AT THREE DIFFERENT SEEDING RATES AND THREE DIFFERENT CLIPPING INTENSITIES IN EACH OF FOUR REPLICATIONS

Seeding Rate Kg/ha	Cut	Row	Grain Yield in Kilograms per Hectare Replications			
			1	2	3	4
66.6	1	3	431	179	538	108
66.6	0	4	1256	1076	1435	969
66.6	1	5	610	179	179	251
66.6	2	7	179	251	359	251
66.6	2	9	359	179	108	108
83.3	1	3	538	538	431	538
83.3	0	4	1328	2332	1256	1328
83.3	1	5	251	538	431	359
83.3	2	7	359	359	179	359
83.3	2	9	108	108	108	179
100	1	3	251	431	431	538
100	0	4	1686	2153	1256	1686
100	1	5	179	359	359	610
100	2	7	179	251	431	431
100	2	9	72	179	108	179

TABLE XV

MEAN FORAGE YIELDS OF THREE RYE VARIETIES AT THREE SEEDING RATES AND DIFFERENT CLIPPING INTENSITIES

Variety	Clipping	Row	Seeding Rate			Average
			66.6	83.3	100	
Bonel	1	3	1076	942	1139	1070
	1	5	1561	1722	1579	1621
	2	7	1090	1162	1467	1239
	2	9	1018	1144	1520	1227
	4	11	1431	1637	1579	1549
Elbon	1	3	1238	942	1229	1136
	1	5	1417	1121	1615	1384
	2	7	1471	1440	1126	1345
	2	9	1215	1408	1597	1407
	4	11	1359	1332	1543	1411
Okema	1	3	502	951	1121	858
	1	5	1148	1381	1533	1354
	2	7	915	1049	1305	1090
	2	9	942	1260	1032	1078
	4	11	1130	1364	1565	1353

TABLE XVI

MEAN GRAIN YIELDS OF THREE RYE VARIETIES AT THREE SEEDING RATES AND DIFFERENT CLIPPING INTENSITIES

Variety	Clipping	Row	Seeding Rate			Average
			66.6	83.3	100	
Bonel	1	3	807	440	601	616
	0	4	1696	1651	1857	1735
	1	5	440	466	386	431
	2	7	395	502	305	401
	2	9	278	269	215	254
Elbon	1	3	727	646	646	673
	0	4	1489	1588	1588	1555
	1	5	574	484	529	529
	2	7	448	664	305	472
	2	9	323	425	305	350
Okema	1	3	314	511	413	413
	0	4	1184	1561	1695	1480
	1	5	305	395	377	359
	2	7	260	314	323	259
	2	9	188	126	135	149

VITA

Mansour Taieb

Candidate for the Degree of

Master of Science

Thesis: FORAGE AND GRAIN YIELDS OF RYE AS AFFECTED BY SEEDING RATES AND CLIPPING

Major Field: Agronomy

Biographical:

Personal Data: Born in Gafsa, Tunisia, July 3, 1946, the son of Ali and Khadija Taieb.

Education: Attended Gafsa Elementary School and graduated from Gafsa High School, Gafsa, Tunisia in June 1967. Attended Faculty of Sciences University of Tunis, Tunisia and received Agricultural Engineer degree from Institut National d'Agronomie, Tunis, Tunisia in June 1972.

Professional Experience: Employed by the Gafsa CRDA, Gafsa, Tunisia during summers of 1965 and 1966. Agency for International Development Fellow, Department of Agronomy, Oklahoma State University, Stillwater, Oklahoma, August 1973 to December 1974.